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Aliberti

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(54) **LIGHT EMITTING DIODE LIGHT BULB AND INCANDESCENT LAMP CONVERSION APPARATUS**

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F21V 29/00 (2006.01)
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(Continued)

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USPC .... 362/294, 249.02; 313/46, 318.04; 315/159, 185 R, 362
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,892,000 B1 2/2011 Yen
7,911,118 B2 3/2011 Rooymans
(Continued)

FOREIGN PATENT DOCUMENTS

KR	1020070118171	12/2007
KR	1020100010321	2/2010
WO	WO2010031723	3/2010

OTHER PUBLICATIONS

PCT Search Report mailed Oct. 18, 2012.

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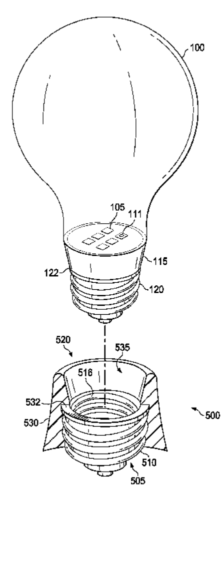
(57) **ABSTRACT**

Apparatus and methods separate the functions of light emission, heat dissipation, and power conversion in LED lighting. Doing so may facilitate cost-effective LED lighting and enable the conversion of existing incandescent lamps to LED service. An LED light bulb includes a thermal path from LED dies to a thermal transfer contact having an externally available surface. The LED light bulb and an incandescent lamp adapter are consumer-installable in an incandescent lamp. A heat spreader component of the lamp adapter contacts the thermal transfer contact of the LED light bulb to dissipate heat originating at the LED dies. A lamp adaptable LED power supply plugs into a standard AC power outlet and includes a receptacle to accept insertion of a lamp cord plug to deliver power to the LED light bulb. A lock-in safety device prevents retraction of the lamp cord plug from the LED power supply once inserted.

15 Claims, 6 Drawing Sheets



(51) **Int. Cl.**

F21K 99/00	(2010.01)
H05B 33/08	(2006.01)
F21V 29/70	(2015.01)
F21V 3/00	(2015.01)
F21Y 101/02	(2006.01)
F21Y 105/00	(2006.01)
F21Y 111/00	(2006.01)
F21V 29/71	(2015.01)

(52) **U.S. Cl.**
CPC ***H05B 33/0803*** (2013.01); *F21V 3/00* (2013.01); *F21V 29/713* (2015.01); *F21Y 2101/02* (2013.01); *F21Y 2105/001* (2013.01); *F21Y 2105/008* (2013.01); *F21Y 2111/004* (2013.01); *F21Y 2111/005* (2013.01); *Y02B 20/383* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,956,546	B2	6/2011	Hasnain
2005/0231964	A1	10/2005	Tufano, Sr. et al.
2007/0268687	A1	11/2007	Scannell, Jr.
2008/0293290	A1	11/2008	Ku et al.
2010/0051976	A1	3/2010	Rooymans
2011/0163678	A1	7/2011	Shew

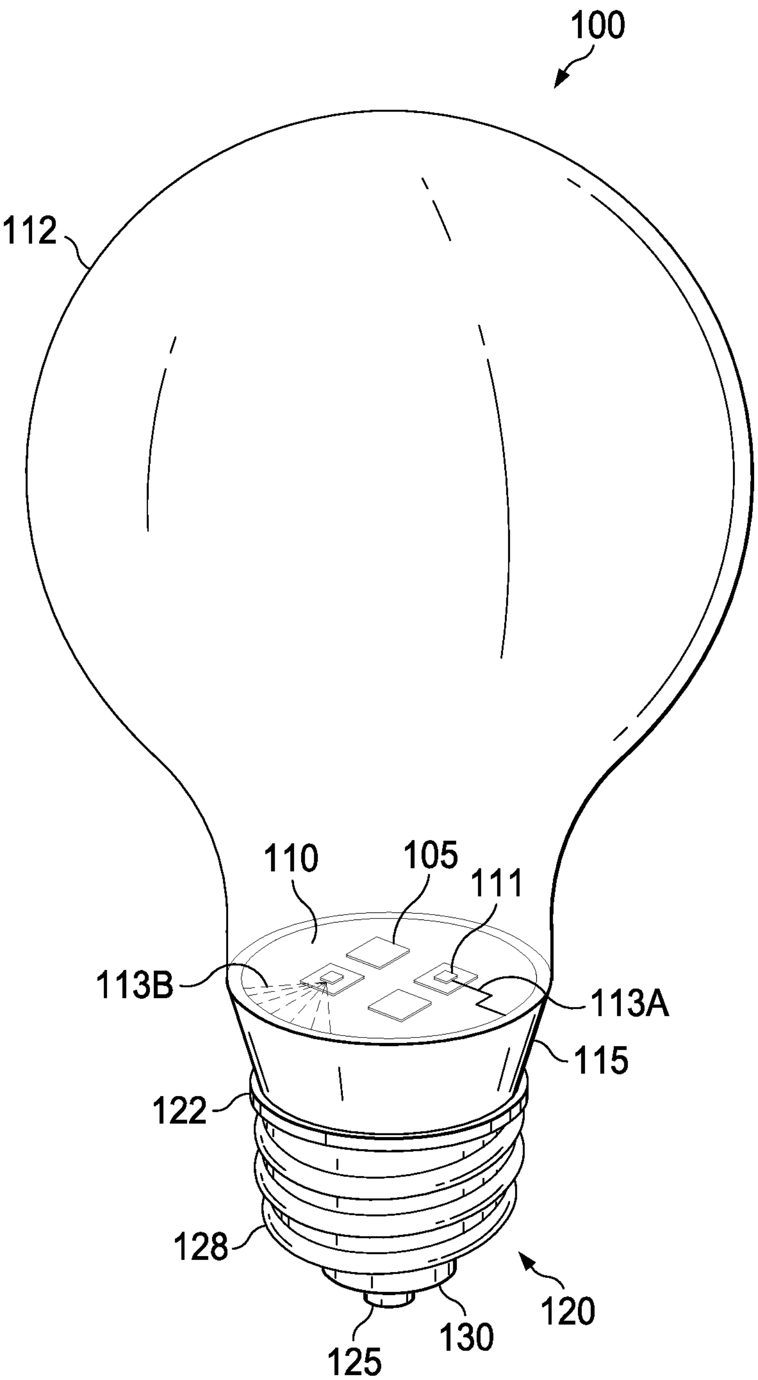


FIG. 1

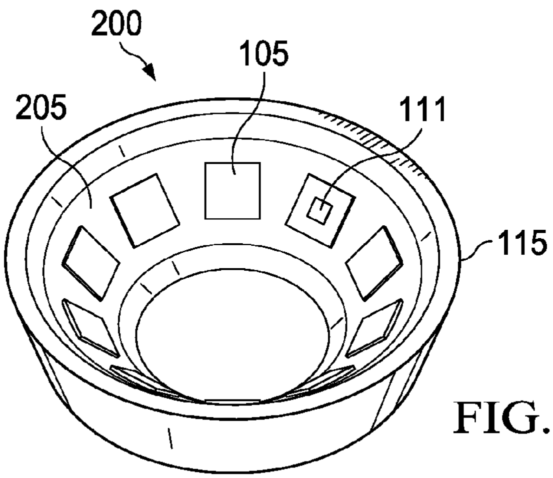


FIG. 2

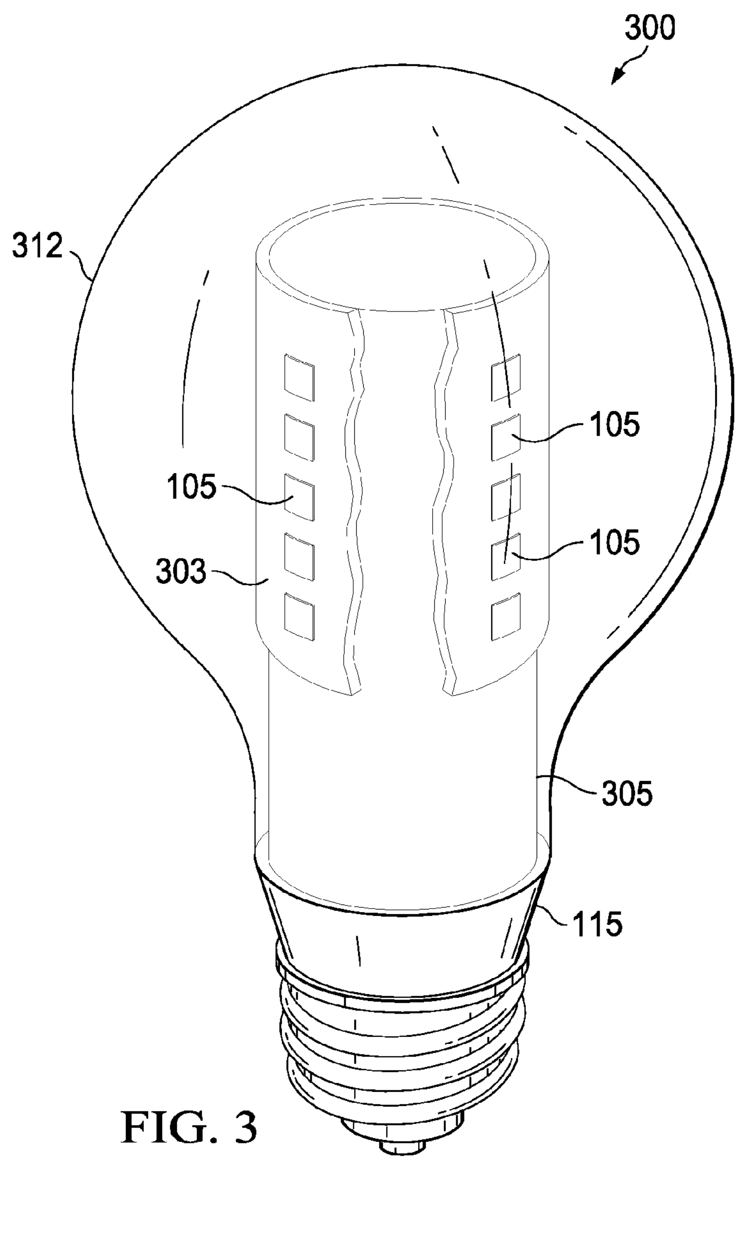


FIG. 3

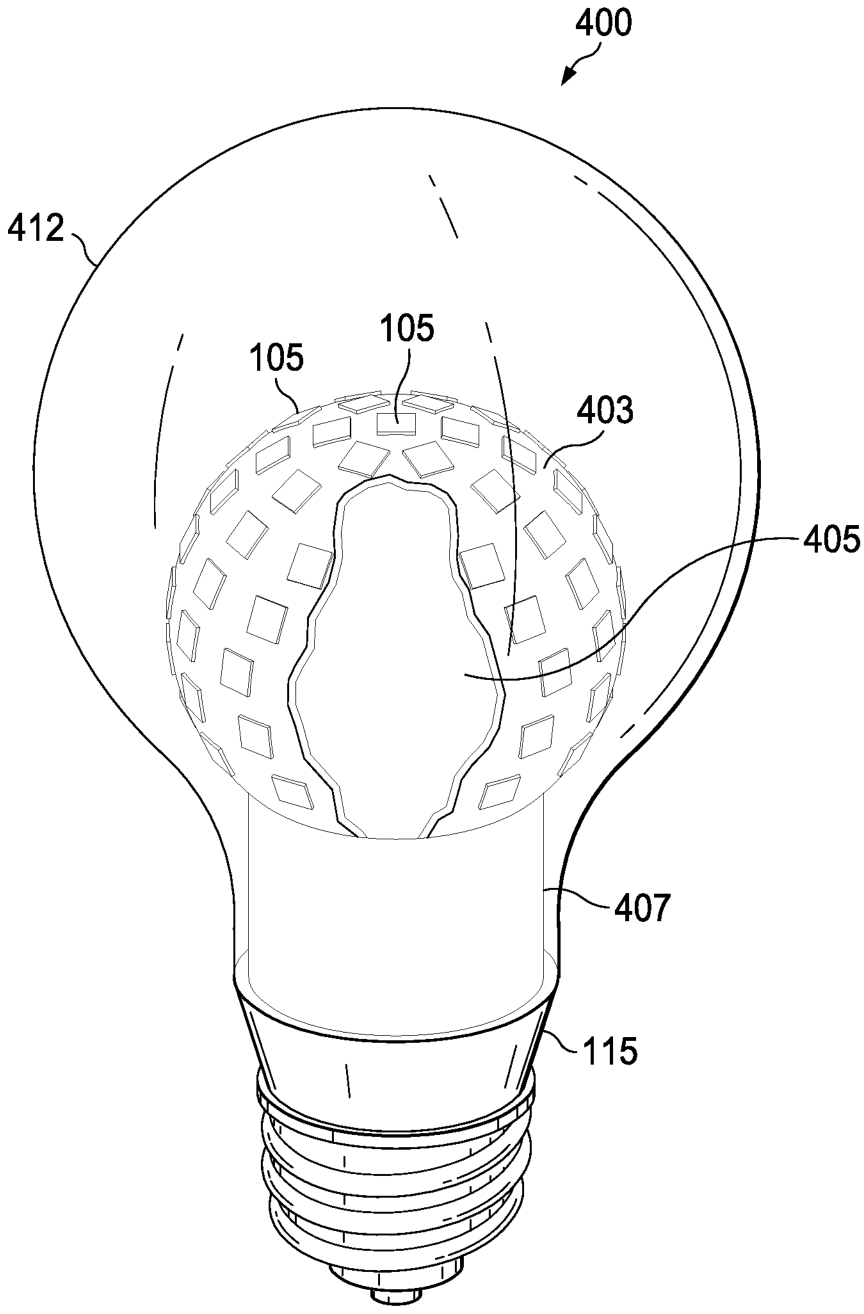


FIG. 4

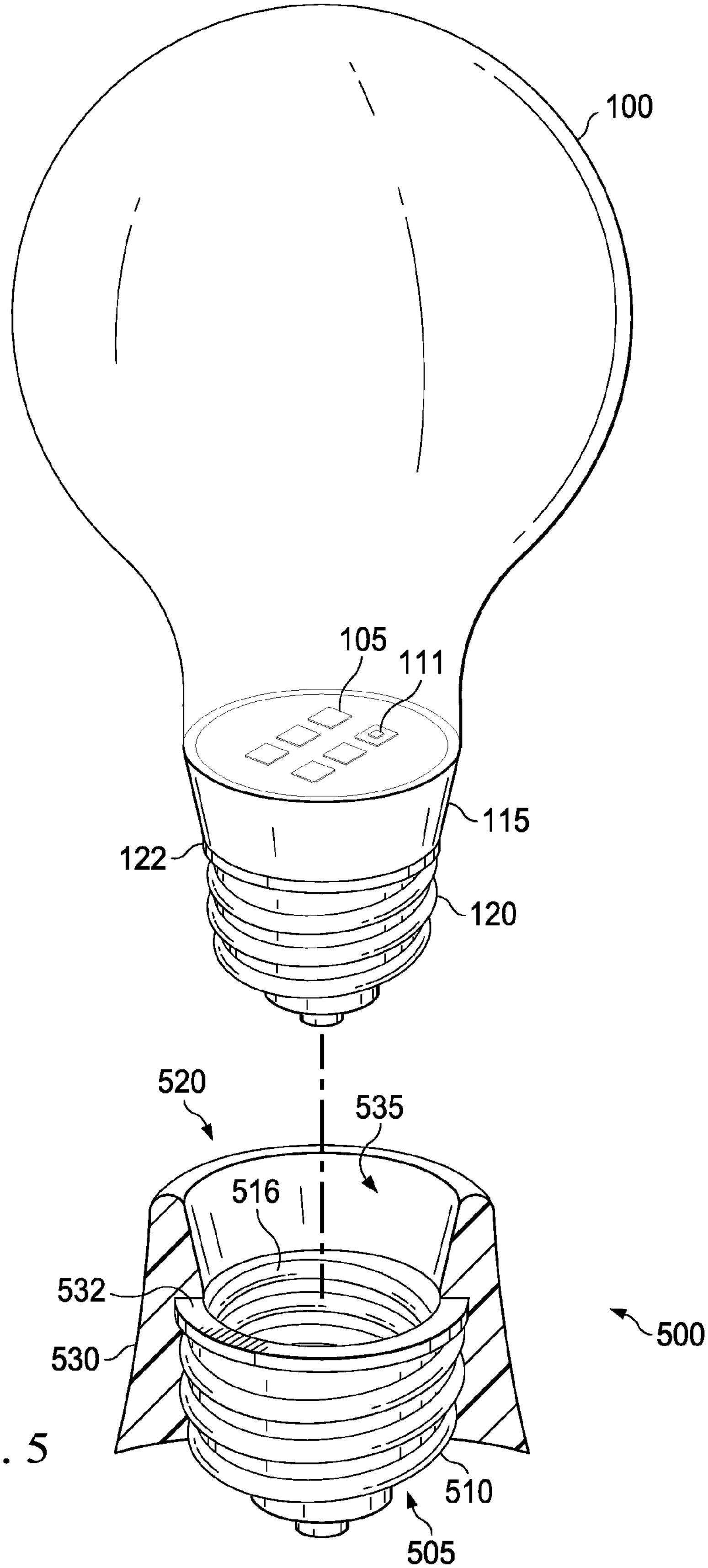


FIG. 5

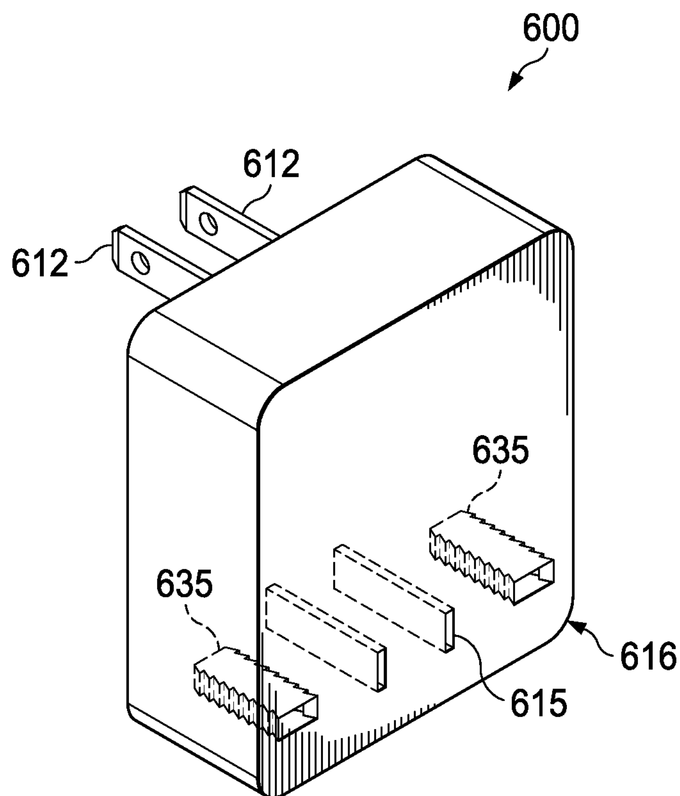


FIG. 6

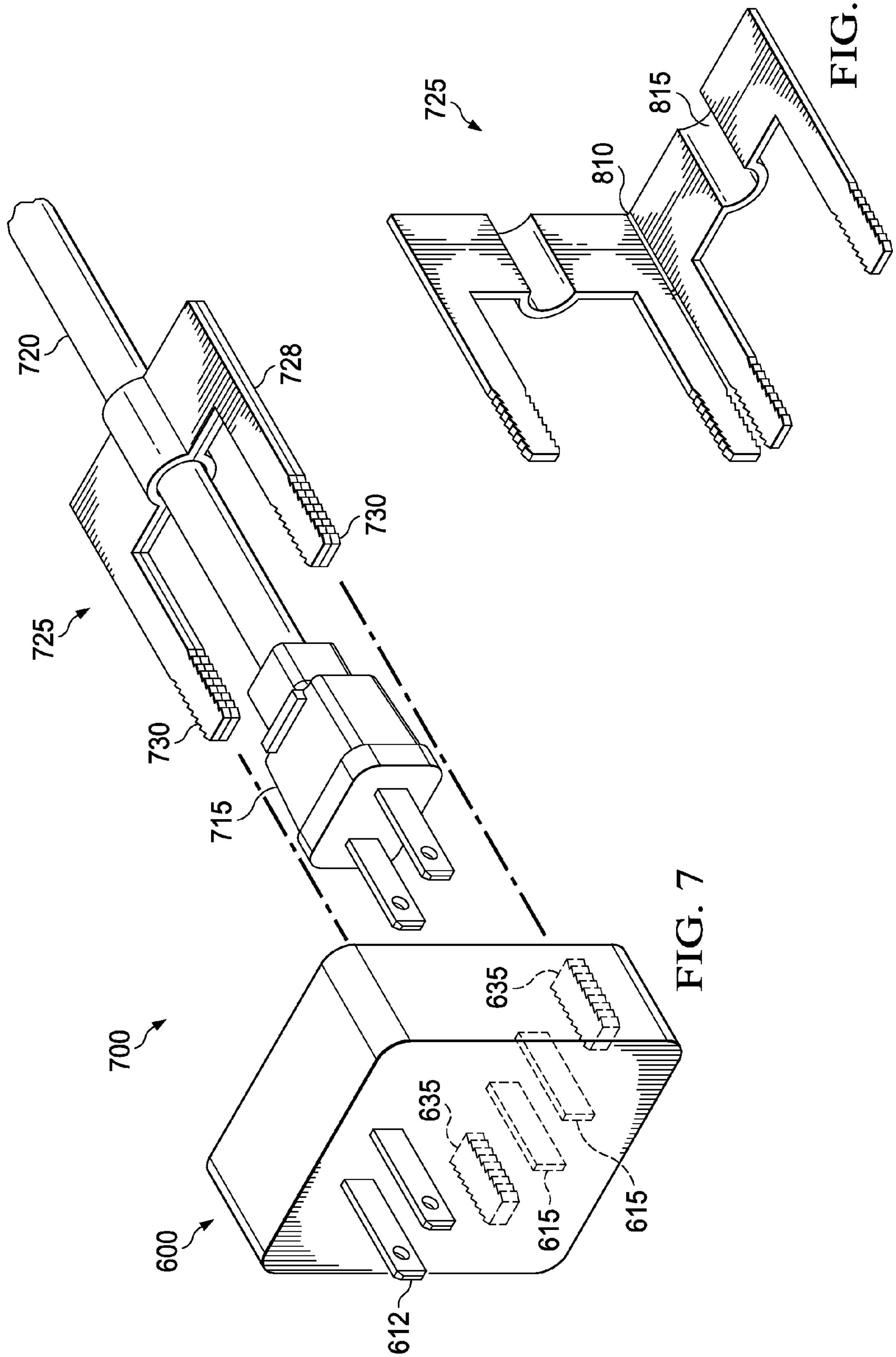


FIG. 7

FIG. 8

LIGHT EMITTING DIODE LIGHT BULB AND INCANDESCENT LAMP CONVERSION APPARATUS

PRIORITY CLAIM

This application is a divisional of U.S. Nonprovisional patent application Ser. No. 13/366,091, filed Feb. 3, 2012 (now U.S. Pat. No. 8,708,525), which claims the benefit of priority under 35 U.S.C. §119(e) to U.S. Provisional Patent Application No. 61/448,496, titled "Incandescent Lamp to LED Lighting Lamp Conversion," filed on Mar. 2, 2011 and incorporated herein by reference in their entireties.

TECHNICAL FIELD

Embodiments described herein relate to ambient space lighting apparatus, including structures and methods associated with light-emitting diode (LED)-based light bulbs, apparatus to adapt LED light bulbs to incandescent lamps, and associated power supplies.

BACKGROUND INFORMATION

Power handling capabilities, power-to-lumen efficiencies, and production costs of LEDs have improved over the past few years. Consequently, LED-based ambient lighting has become practical and has begun to compete with compact fluorescent lighting (CFL) technologies as a replacement for power-hungry incandescent lighting.

Challenges to LED lighting include power conversion and heat dissipation requirements. LED arrays typically require low-voltage direct current (DC) and are driven by residential voltage alternating current (AC) to constant current DC power supplies. Light conversion in incandescent bulbs occurs along the filament. Heat from the unconverted power is dissipated from the filament and down through the filament support elements connecting the filament to the base. Light conversion in CFL bulbs occurs via luminescence across a substantial percentage of the interior surface area of the bulb. Heat from unconverted power in the CFL case is generated by the associated mercury vapor discharge process throughout the interior of the bulb and by the ballast circuitry at the base. In the cases of both incandescent and CFL bulbs, waste heat is generated and conducted across relatively large surface areas.

In contrast, a power LED useful for ambient lighting emits light and produces heat across a millimeter-scale semiconductor die surface, resulting in a very high heat flux (watts per unit area). The power efficacy in lumens per watt is much higher for LED lighting as compared to incandescent and is beginning to outpace the efficacy of CFL bulbs. Said differently, LED lighting produces less heat per lumen than the other two technologies. However, the high heat flux resulting from the very small emission surfaces associated with LED dies creates a considerable waste heat removal problem. Consequently, commercially available direct-replacement LED bulbs typically include bulky, complex heat dissipation elements as well as AC to constant current DC internal power supplies. The incorporation of these support apparatus into each LED light bulb currently disadvantages LED lighting's initial cost to performance ratio as compared to that of older technologies.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an LED light bulb according to various example embodiments of the invention.

FIG. **2** illustrates a thermal transfer contact configuration including LED packages positioned at a thermal transfer contact according to various example embodiments.

FIGS. **3-4** illustrate LED light bulbs according to various example embodiments.

FIG. **5** illustrates an LED light bulb lamp adapter according to various example embodiments.

FIG. **6** illustrates a lamp adapter LED power supply module according to various example embodiments.

FIG. **7** illustrates a lamp adapter LED power supply assembly according to various example embodiments.

FIG. **8** illustrates a lamp plug lock-in device according to various example embodiments.

SUMMARY OF THE INVENTION

Embodiments herein separate the functions of light emission, heat dissipation, and power conversion in LED lighting. Doing so may facilitate production of a cost-effective LED light bulb and enable the conversion of existing incandescent lamp lighting to LED lighting service.

Embodiments of an LED light bulb herein disclosed include thermal paths from LED dies mounted in LED packages to an integrated thermal transfer contact having an externally available surface. The LED light bulb is consumer-installable in a female end of an incandescent lamp adapter. The lamp adapter includes an industry-standard lamp bulb base and is thus capable of being installed in an incandescent lamp as though it were an incandescent light bulb. The lamp adapter also includes a heat spreader. With the LED light bulb installed in the lamp adapter, the heat spreader contacts the light bulb's thermal transfer contact and dissipates heat originating at the LED dies.

Some embodiments may also include a lamp adaptable LED power supply. The LED power supply plugs into a standard AC power outlet and provides power suitable for the particular technology associated with the LED dies integrated into the LED light bulb. The LED power supply includes a receptacle into which a lamp cord plug from the LED-converted lamp may be inserted. A lock-in device prevents retraction of the lamp cord plug from the LED power supply, once inserted. The lock-in device helps to ensure that the lamp, once converted for use as an LED lamp, is not inadvertently plugged into a standard AC power outlet.

DETAILED DESCRIPTION

FIG. **1** illustrates an LED light bulb **100** according to various example embodiments of the invention. The LED light bulb **100** includes one or more LED packages **105** mounted on a substrate **110**. Each of the LED packages **105** includes one or more LED dies (e.g., the die **111**). The LED dies **111** may be manufactured according to various evolving processes and technologies, including but not limited to an organic LED process, a polymer LED process, a quantum dot LED process, a half-cycle AC LED process, and/or a process incorporating electroluminescence.

In some embodiments, the package-carrying substrate **110** may comprise a conductor-carrying electrical insulation material such as a rigid circuit board or a flex circuit, for example. In some embodiments, the LED package-carrying substrate **110** may be configured as two or more electrically isolated portions of a heat sink incorporated into the LED light bulb **100**. In the latter case, the LED packages **105** may be affixed directly to the electrically isolated portions of the heat sink.

The LED light bulb **100** also includes one or more thermal conductors (e.g., the thermal conductors **113**A and/or **113**B). The thermal conductors **113**A, **113**B are coupled to the LED dies **111** to transfer heat away from the dies **111**. In some embodiments, thermal conductors (e.g., the conductor **113**A) may also serve as electrical connections to the dies **111**, and may be configured as paths on and/or through the substrate **110**. In embodiments with LED packages affixed directly to a segmented heat sink, the thermal conductors (e.g. the conductors **113**B) may be embodied in the heat sink itself.

The LED light bulb **100** also includes one or more integral thermal transfer contacts (e.g., the thermal transfer contact **115**). In this context, "integral" means integrated as an element of the LED light bulb **100**. In some embodiments, the thermal transfer contact **115** may be formed in the shape of a band around the perimeter of the LED light bulb **100**, as depicted in FIG. **1**. Many other embodiments of the thermal contact **115** are contemplated by this disclosure. One or more surfaces of the thermal transfer contact **115** are configured to thermally contact a heat sink external to the LED light bulb **100**. The thermal transfer contact **115** is thermally coupled to the thermal conductors **113**A, **113**B to transfer heat away from the LED dies **111** and to the external heat sink.

The LED light bulb **100** also includes a base **120** coupled to the thermal transfer contact **115**. The base **120** may be electrically coupled to the thermal transfer contact **115** or maybe insulated therefrom by an insulator **122**. The base **120** supports the LED light bulb **100** in a socket and provides electrical conductors to deliver power to the LED packages **105**.

The base **120** may be configured physically and electrically to be easily installed by a consumer. Embodiments of the base **120** are configured to preclude installation into a standard 26 mm (USA E26) or 27 mm (EU E27) Edison screw base lamp socket for safety reasons. Appropriate configurations of the base **120** disclosed herein include an Edison screw base less than 26 millimeters in diameter at the envelope (smaller than E26), a base with at least one protruding prong to make electrical contact with a corresponding receptacle at the socket, or a bayonet-style base, among others.

In embodiments using a smaller-than-standard Edison screw base, the base **120** may include a central electrical contact **125**. The contact **125** may be electrically insulated from threads **128** by an insulator **130**. Electrical power to the LED packages **105** may be delivered via the contact **125**, the threads **128**, and/or the thermal transfer contact **115**. In some embodiments, for example, a heat-generating cathode of the LED die **111** may be electrically connected to the thermal transfer contact **115**. In the latter case, the thermal transfer contact **115** may be configured to provide an electrical connection to one or more elements of the base **120** absent the insulator **122**, or to the external heat sink with the insulator **120** present.

The LED light bulb **100** also includes a light-transmissive envelope **112** extending from the thermal transfer contact **115**, the base **120**, or both. The envelope **112** surrounds and protects the LED packages **105** and may be used to grasp the LED light bulb **100** during installation.

The LED packages **105** may be variously positioned in LED light bulbs described herein. Factors to consider include thermal transfer of waste heat generated by the LED dies **111**, delivery of electrical power, and light direction and diffusion, among others. Accordingly, the following embodiments are example implementations of structures capable of accommodating high-power LED dies by efficiently sinking large amounts of heat via transfer to an external heat sink via the heat transfer contact **115**.

FIG. **2** illustrates a thermal transfer contact configuration **200** including LED packages **105** positioned at the thermal transfer contact **115** according to various example embodiments. An LED package-carrying substrate **205** is affixed around an inner circumference of the thermal transfer contact **115**. The configuration **200** provides for close thermal coupling between LED packages **105** and the thermal transfer contact **115**. Heat generated by the LED dies **111** may be efficiently transferred from the LED bulb **100** to the external heat sink as a result. The beveled interior shape of the thermal transfer contact **115** positions the LED packages **105** to emit light for 360° at an upward pitch from the horizontal. The resulting light path may provide for enhanced light dispersion resembling that of an incandescent lamp.

FIGS. **3**-**4** illustrate LED light bulbs **300** and **400** according to various example embodiments. The LED light bulb **300** includes a substantially cylindrically-shaped LED package-carrying substrate **303** affixed around a cylindrical heat sink **305**. The heat sink **305** is thermally coupled to the thermal transfer contact **115**. The LED packages **105** are thus thermally coupled to the thermal transfer contact **115** via the heat sink **305**. In some embodiments, LED packages **105** may be affixed directly to an electrically-segmented version of the heat sink **305**, as previously described with reference to FIG. **1**. In some embodiments, the substrate **303** and the heat sink **305** may be enclosed by a transmissive envelope **312**. The transmissive envelope **312** is adapted to accommodate the size, shape, and/or heat transfer characteristics of the LED packages **105** and the cylindrical heat sink **305**.

Turning now to FIG. **4**, the LED light bulb **400** includes LED package-carrying substrate **403**. The substrate **403** is affixed around an ellipsoidally-shaped heat sink **405**. In some embodiments, the heat sink **405** may be spherically-shaped. A cylindrical extension **407** of the heat sink **405** is thermally coupled to the thermal transfer contact **115**. In some embodiments, the LED packages **105** may be affixed directly to an electrically-segmented version of the heat sink **405**, as previously described with reference to FIG. **1**. A transmissive envelope **412** may be adapted to accommodate the size, shape, and/or heat transfer characteristics of the LED packages **105** and the ellipsoidal heat sink **405**.

FIG. **5** illustrates an LED light bulb lamp adapter **500** according to various example embodiments. The lamp adapter **500** includes an adapter base **505**. The adapter base **505** is adapted at a male end **510** to be installed in a standard incandescent light bulb socket. For example, the male end **510** of the adapter base **505** may be configured as an Edison screw 26 millimeter base (USA standard E26) or an Edison screw 27 millimeter base (European standard E27).

The adapter base **505** is adapted at a female end **516** to accept an LED light bulb such as the bulbs **100**, **300**, and **400** previously described with reference to FIGS. **1**, **3**, and **4** (hereinafter "LED light bulb **100**"). The female end **516** of the adapter base **505** may be configured to accept an Edison screw base less than 26 millimeters in diameter (smaller than E26), a bayonet base, or a base with one or more protruding prongs to make electrical contact with a corresponding receptacle at the female end **516** of the adapter base **505**.

The lamp adapter **500** also includes a heat sink. The heat sink may be configured in various shapes and sizes in various embodiments of the lamp adapter **500**. For example, a heat spreader **520** may be formed as a skirt **530** surrounding the adapter base **500** and may be mechanically coupled to the adapter base **505** for support. Some embodiments of the adapter **500** may also include an insulator **532**. The insulator **532** electrically isolates the heat spreader **520** from the adapter base **505**. The latter embodiment may be used in conjunction with an LED light bulb **100** having a base **120** isolated from thermal transfer contact **115** by electrical isolator **122**.

A surface **535** of the heat spreader **520** is capable of being thermally coupled to the thermal transfer contact **115** of the LED light bulb **100**. So coupled, the heat spreader **520** sinks and dissipates heat from the LED packages **105** through the thermal transfer contact **115** when the LED light bulb **100** is installed in the adapter base **500**. Configurations of the thermal transfer contact **115** and the heat spreader **520** are described herein as examples of apparatus used to separate illumination functionality from heat dissipation functionality. Doing so may improve the efficiency of either or both functions. For example, a heat sink external to the LED light bulb **100** may be larger than might be practical if integrated into the light bulb **100** and/or situated in close proximity to the LED packages **105**. The entire body of a metal lamp or a portion thereof may be thermally coupled to the thermal transfer contact **115** to operate as a heat sink. Greater heat sink efficiency may allow the LED dies **111** to be over-driven to produce more light at cooler die temperatures.

FIG. **6** illustrates a lamp adapter LED power supply module **600** according to various example embodiments. The power supply module **600** includes electrical contact prongs **612**. The contact prongs **612** are adapted to plug into a standard electrical outlet and/or electrical extension cord, the particulars of which may very according to local jurisdiction and electrical codes. U.S. plugs and receptacles are illustrated herein as examples. The power supply module **600** is adapted to utilize AC current from an electrical outlet and to provide electrical power appropriate to power one or more LED components associated with an LED light bulb. For example, the power supply module **600** may be configured as a constant current DC source or as a half-cycle AC current source, among others and as appropriate to evolving LED technologies.

The power supply module **600** also includes an integral electrical receptacle **615**. The electrical receptacle **615** is adapted to accept electrical contact prongs associated with a lamp cord plug inserted into the power supply module **600**. The power supply module **600** further includes channels **635** extending into the module **600** from the module surface **616**. The channels **635** are adapted to accept extension elements of a lamp plug lock-in retainer as further described below. It is noted that the power supply module **600** may be configured in various shapes and sizes as dictated by the interior volume and shape requirements of the included electrical components, consumer convenience, etc. For example, in some embodiments the electrical receptacle **615** and the lock-in channels **635** may be positioned along a side face of the module **600** rather than along the broad face as depicted in FIG. **6**.

FIG. **7** illustrates a lamp adapter LED power supply assembly **700** according to various example embodiments. The power supply assembly **700** includes the power supply module **600** as previously described. The assembly **700** also includes a lock-in device **725**. The lock-in device **725** is adapted to couple to the power supply module **600** and to a lamp cord plug **715** inserted into the power supply module **600**. The lock-in device **725** prevents retraction of the lamp cord plug **715** from the power supply module **600**.

In some embodiments, the lock-in device **725** may include a lateral portion **728**. The lateral portion **728** is coupled to one end of each of two or more retainer extensions **730**. The lateral portion **728** supports and maintains spacing between the retainer extensions **730**. The retainer extensions **730** are adapted to surround a portion of the lamp cord plug **715** and are capable of insertion into the lock-in channels **635** integrated into the power supply module **600**. The lateral portion **728** abuts the lamp cord plug **715** to inhibit extraction of the lamp cord plug **715** following initial insertion of the retainer extensions **730** into the lock-in channels **635**.

In some embodiments, the lock-in device retainer extensions **730** may include serrations along one or more edges and along corresponding edges of the lock-in channels **635**. The serrations may be formed into substantially sawtooth shapes. Such arrangement may facilitate insertion of the lock-in device retainer extensions **730** into the lock-in channels **635** and inhibit removal of the lamp cord plug **715** from the power supply **600** once inserted.

FIG. **8** illustrates an LED lamp plug lock-in device **725** according to various example embodiments. In some embodiments, the lock-in device **725** may be formed in a clamshell configuration (e.g., injection molded) to facilitate installation around the lamp cord **720** of FIG. **7** prior to insertion into the lock-in channels **635**. The two portions of the clamshell may be joined by a hinge **810** (e.g., a molded plastic extension of each of the two portions). The two portions may also each include a channel **815** to fit around the lamp cord **720**.

An incandescent to LED lamp conversion kit may be packaged to include one or more of the LED light bulbs **100** previously described with reference to FIGS. **1-4**. LED light bulbs in the conversion kit are adapted to be installed in LED light bulb lamp adapters **500** previously described with reference to FIG. **5**. A lamp adapter **500** from the conversion kit is adapted for installation in an incandescent lamp in place of an incandescent bulb. Waste heat from an LED light bulb installed from the conversion kit is transferred through a thermal transfer contact **115** integral to the LED bulb to a heat sink portion **520** of the lamp adapter **500**, as previously described with reference to FIG. **5**. A lamp-adaptable LED power supply assembly **700** as described with reference to FIGS. **6-8** is also included in the conversion kit. An LED power supply module **600** is adapted to plug into a standard electrical outlet. The power supply **600** is also adapted to lock in a lamp cord plug **715** inserted into the LED power supply module **600** and to supply appropriate power to the LED light bulb(s).

Modules and components described herein may include hardware circuitry, optical components, single or multi-processor circuits, memory circuits, and/or articles of manufacture including computer-readable media with computer instructions encoded therein/thereon capable of being executed by a processor, and including non-volatile memory with firmware stored therein (but excluding non-functional descriptive matter), and combinations thereof, as desired by the architects of the LED light bulbs **100**, **300**, **400**, the lamp adapter **500**, the LED power supply assembly **700**, and as appropriate for particular implementations of various embodiments.

Apparatus and systems described herein may be useful in applications other than incandescent to LED lamp conversion. Other applications may exist for the LED light bulbs **100**, **300**, **400**, for the lamp adapter **500**, and for the LED power supply assembly **700**. Examples of these apparatus described herein are intended to provide a general understanding of the structures of various embodiments. They are not intended to serve as complete descriptions of all elements and features of apparatus and systems that might make use of these structures.

Apparatus and methods described herein separate the functions of light emission, heat dissipation, and power conversion in LED lighting. Doing so may facilitate cost-effective LED lighting and enable the conversion of existing incandescent lamps to LED service. An LED light bulb includes a thermal transfer contact to transfer LED die-generated heat to a heat sink external to the bulb. A lamp adapter safely routes power from a lamp adaptable LED power supply through the lamp to the LED light bulb.

By way of illustration and not of limitation, the accompanying figures show specific embodiments in which the subject matter may be practiced. It is noted that arrows at one or both ends of connecting lines are intended to show the general direction of electrical current flow, data flow, logic flow, etc. Connector line arrows are not intended to limit such flows to a particular direction such as to preclude any flow in an opposite direction. The embodiments illustrated are described in sufficient detail to enable those skilled in the art to practice the teachings disclosed herein. Other embodiments may be used and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. This Detailed Description, therefore, is not to be taken in a limiting sense. The breadth of various embodiments is defined by the appended claims and the full range of equivalents to which such claims are entitled.

Such embodiments of the inventive subject matter may be referred to herein individually or collectively by the term "invention" merely for convenience and without intending to voluntarily limit this application to any single invention or inventive concept, if more than one is in fact disclosed. Thus, although specific embodiments have been illustrated and described herein, any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments.

The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b) requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In the preceding Detailed Description, various features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted to require more features than are expressly recited in each claim. Rather, inventive subject matter may be found in less than all features of a single disclosed embodiment. The following claims are hereby incorporated into the Detailed Description; with each claim standing on its own as a separate embodiment.

What is claimed is:

1. A light emitting diode (LED) light bulb, comprising:

a least one LED package mounted on a substrate, the LED package to include an LED die;

at least one thermal conductor coupled to the LED die to transfer heat away from the LED die; and

a thermal transfer contact thermally coupled to the thermal conductor, at least one surface of the thermal transfer contact configured to thermally contact a heat sink external to the LED light bulb.

2. The LED light bulb of claim **1**, further comprising:

a base to support the LED light bulb in a socket and to provide electrical conductors to deliver power to the LED packages; and

a light-transmissive envelope extending from at least one of the base or the thermal transfer contact to surround and protect the LED package and to be used to grasp the LED light bulb during installation.

3. The LED light bulb of claim **2**, the base configured as at least one of an Edison screw base less than 26 millimeters in diameter at the envelope (E26), a bayonet base, or a base with

at least one protruding prong to make electrical contact with a corresponding receptacle at the socket.

4. The LED light bulb of claim **2**, the thermal transfer contact formed in the shape of a band at a perimeter of the LED light bulb.

5. The LED light bulb of claim **4**, the LED package-carrying substrate affixed around an inner circumference of the thermal transfer band.

6. The LED light bulb of claim **2**, the thermal transfer contact configured to provide an electrical connection between the LED package and at least one of the base or the external heat sink.

7. The LED light bulb of claim **2**, the base further comprising:

a center electrical contact situated at the bottom of the base and electrically isolated from the base to provide an electrical connection from an external power source to the LED package.

8. The LED light bulb of claim **1**, the LED die manufactured according to at least one of an organic LED process, a polymer LED process, a quantum dot LED process, a half-cycle AC LED process, or a process incorporating electroluminescence.

9. The LED light bulb of claim **1**, the package-carrying substrate comprising at least one of a rigid circuit board, a flex circuit, or a heat sink to include at least two electrically conductive portions, each portion electrically isolated from the other portion.

10. The LED light bulb of claim **1**, the LED package-carrying substrate affixed around a cylindrical heat sink thermally coupled to the thermal transfer contact.

11. The LED light bulb of claim **1**, the LED package-carrying substrate affixed around an ellipsoidally-shaped heat sink, a cylindrical extension of the heat sink thermally coupled to the thermal transfer contact.

12. An LED light bulb lamp adapter, comprising:

an adapter base to fit to an incandescent light bulb socket and to accept an LED light bulb; and

a heat spreader mechanically coupled to the adapter base for support and capable of thermal coupling to a thermal transfer contact associated with the LED light bulb, the heat spreader to sink and dissipate heat from the LED light bulb when the LED light bulb is operating in the adapter base.

13. The LED light bulb lamp adapter of claim **12**, a male portion of the adapter base configured as at least one of an Edison screw 26 millimeter base (USA standard E26) or an Edison screw 27 millimeter base (European standard E27), and a female portion of the adapter base configured to accept at least one of an Edison screw base less than 26 millimeters in diameter (E26) associated with the LED light bulb, a bayonet base, or an LED light bulb base with at least one protruding prong to make electrical contact with a corresponding receptacle at the internal portion of the adapter base.

14. The LED light bulb lamp adapter of claim **12**, the heat spreader formed as a skirt surrounding the adapter base.

15. An incandescent-to-LED lamp conversion kit, comprising:

a light emitting diode (LED) light bulb including at least one LED package mounted on a substrate to support an LED die, at least one thermal conductor coupled to the LED die to transfer heat away from the LED die, and a thermal transfer contact thermally coupled to the thermal conductor, at least one surface of the thermal transfer contact configured to thermally contact a heat sink external to the LED light bulb;

an LED light bulb lamp adapter including an adapter base configured for installation in an incandescent light bulb socket to accept the LED light bulb and a heat spreader mechanically coupled to the adapter base for support, the heat spreader capable of thermal coupling to the thermal transfer contact to sink and dissipate heat from the LED light bulb when the LED light bulb is operating in the adapter base; and

a lamp adaptable LED power supply assembly including a power supply module capable of electrical connection to an electrical outlet, the power supply module adapted to utilize AC current from the electrical outlet and to provide electrical power appropriate to at least one LED component of the LED light bulb, an electrical receptacle component of the power supply module to accept electrical contact prongs associated with a lamp cord plug, and a lock-in device to couple to the lamp cord plug and to the power supply module to prevent retraction of the lamp cord plug from the power supply module.

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